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THE VARIATIONS OF GLACIERS. IX[1]

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The following is a summary of the Ninth Annual Report of the International Committee on Glaciers:[2]

REPORT ON GLACIERS FOR 1903

Swiss Alps.—Of the ninety glaciers under the care of the Swiss foresters, fifty-eight were measured in 1903; the larger number, forty-three, are receding or stationary, and this is evidently the condition of the large majority of the Swiss glaciers. The slight tendency to increase shown last year by thirteen glaciers continues. Three glaciers have been certainly increasing for the last three years; twelve have been increasing for a year or two.

Between 1902 and 1903 the Rhone glacier has receded 11.5^{m} and has uncovered an area of $4{,}900^{sq\ m}$. There have been a slight thinning in the lower part of the glacier and a slight thickening higher up.[3]

Eastern Alps.—We have reports from twenty-nine glaciers, eighteen of which are retreating, six are about stationary, and five are advancing.

In the Silvretta group, two glaciers continue to retreat. The Suldenferner in the Ortler group has advanced more than 70^{m} between 1895 and 1903, nearly one-half of which occurred between 1901 and 1903. This glacier is being carefully observed. In the Oetzthal the Hochjochferner and the Hintereisferner are retreating, whereas the Vernagtferner and the Diemferner show slight evidence of advance. The Hochjoch has retreated 2.3^{m}, and the Vernagt has advanced 5^{m}. The Hintereis is growing thinner in the lower part, but has become slightly thicker in the upper part. The glaciers of the Stubaï group, which, in general, have been retreating since 1891, are now retreating much more slowly; and one of them, the Sulzenauferner, has advanced 6.5^{m}. In the Zillerthal the Rainbachkees has retreated 4.4^{m}. Six glaciers of the Venediger group are retreating quite rapidly and three are about stationary. The glaciers of the Glockner are all retreating. Two glaciers of the Ankogel group, the Hochalmkees and the Kleinelandkees, are retreating at the rate of 7 or 8^{m} per year. The Grosselendkees, on the other hand, lying between the other two, has advanced over 2^{m}.

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[1] The earlier reports appeared in the *Journal of Geology*, Vols. III–XII.

[2] *Archives des sciences physiques et naturelles* (Geneva, 1904), Vol. XVIII, pp. 160–95.

[3] Report of Professor Forel and M. Muret.

Italian Alps.—Two secondary glaciers of the Marmarole group are retreating. The other glaciers of the Venetian Alps are retreating slightly or are stationary. All the snow-fields of the Cavallo have increased considerably in size, whereas those of the western slope of the Zoldo have diminished very much since 1888. The glaciers of the Graian and Pennine Alps, in general, have retreated slightly. There seem to be marked increases in the accumulation of snow in the reservoirs of the Brenva glacier and of the glaciers on the Grivola and Grand-Paradis. A discussion of all the observations at hand regarding the glaciers of Valnontey has shown indirectly, but rather strikingly, the slight advance of 1891 which, unfortunately, was not actually measured.[1]

French Alps.—The second report of the French Commission on Glaciers, published in 1903, contains a detailed account of many glaciers and a very comprehensive review of glaciology.[2]

A number of glaciers of Mount Pelvoux advanced slightly in 1890–91, but have retreated ever since; and many of the smaller glaciers have diminished so much in size as to indicate that they may disappear altogether. The glaciers of the Grandes-Rousses have been retreating for the last thirty years, with a slight interruption for some of them about 1890. The glaciers of the Maurienne and of the Tarentaise have shown changes in opposite directions, but for the great majority the retreat has continued, with a tendency toward a slower retreat for the larger glaciers. It is rather interesting to note that the largest glaciers have retreated the least. A comparison

[1] Reports of Professors Porro, Marinelli, and Marson.

[2] By M. Charles Rabot.

of the present position of glaciers with their positions indicated on the maps made about forty years ago shows that the average annual retreat during that period has been about three times as great as the annual retreat during the last decade.[1]

Scandinavian Alps: Norway.—The glaciers of the Jotunheim show, in general, a slight advance between 1901 and 1903. In this region the snowfall has been unusually heavy, some of the glaciers being entirely covered with snow throughout the whole summer of 1903. The same can be said for the glaciers of the Folgefon. There has also been an excessive snowfall in the Jostedal, but the glaciers there have continued to recede slightly.[2]

The Caucasus.—A number of new glaciers have been visited and described, but no information is given regarding their variations, with the exception of one on Mount Bazar-Duzi, which seems to be in retreat.

The Tyan Shan.—In this mountain chain the snowfall has increased very materially. In June, 1903, the glaciers seem to have been entirely snow-covered. A record of the rainfall in the neighborhood shows that it was more than twice as great in 1902–3 as in 1900–1. A glacier resembling the Mer de Glace, and as large as any in the Alps, has been discovered and mapped in the Alatau Mountains of Ili.

Canada.—After an almost normal winter, the observed glaciers in British Columbia and Alberta exhibit most interesting changes since last year. Of the four carefully observed, two are advancing and two continue to recede.

The Victoria glacier, Alberta, continues to recede and also to contract in width. The average shrinkage on the northwest side for the past three years is nineteen feet per year. There is a very evident decrease in the thickness of the ice, and an increase in the number of crevasses at the upper part of the left-hand side. The tongue, deeply buried in moraine, is evidently receding.

The Wenchumna glacier, Alberta, has apparently been advancing for a number of years; it has not been visited until recently, so that the rate of advance cannot yet be determined. Its condition is evidenced by inroads into a living forest composed of large trees which

[1] Report of Professor Killian.

[2] Reports of Messrs. Oyen and Reckstadt.

are being plowed down by great masses of moraine advancing before the ice.

The Illecillewaet glacier, British Columbia, continues to recede and to decrease in thickness. The following table shows the yearly recession determined annually in August since 1898:

1898–1899	11 feet
1899–1900	69 feet
1900–1901	15 feet
1901–1902	48 feet
1902–1903	33 feet

A careful triangulation of the plates placed on the ice in 1899 to determine the rate of flow proves that the rate determined in 1900 has subsequently remained almost constant.

While the Asulkan glacier has apparently shrunk in breadth, the tongue continues to advance. The following shows the principal changes yearly since 1899:

1899–1900	recession, 24 feet
1900–1901	advance, 4 feet
1901–1903	advance, 36 feet[1]

REPORT ON THE GLACIERS OF THE UNITED STATES FOR 1904[2]

Professor George Davidson has made a careful study of all the old charts and narratives relative to the glaciers along the Alaskan coast.[3] He has incorporated in his account copies of some early maps, and has superposed upon them the outlines of the latest maps, and by this means has shown changes that have occurred in the position of the ends of some glaciers. The account is very full, giving, with references, all the descriptions of glaciers by the early navigators. Professor Davidson's general conclusions are practically the same as those arrived at by the Harriman Expedition, namely, that there has been a very marked general retreat of the glaciers, with some exceptions, among which are the glaciers southwest of Mount Fairweather.

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[1] Report of Messrs. George and William S. Vaux, Jr.

[2] A synopsis of this report will appear in the *Tenth Annual Report of the International Committee.* A report of the glaciers of the United States for 1903 was given in this *Journal,* Vol. XII, pp. 258–63.

[3] "The Glaciers of Alaska That Are Shown on Russian Charts or Mentioned in Older Narratives," *Transactions and Proceedings of the Geological Society of the Pacific,* Vol. III, Ser. II, pp. 1–98.

The two glaciers of Taku Inlet were greatly effected by the earthquakes of 1899, but are apparently making up a part of their losses. (*Davidson.*)

There are a large number of small glaciers at the heads of the valleys tributary to Lake Chelan, Washington. One of these, at the head of Railroad Creek, has retreated 200 feet in recent years; and other glaciers in the neighborhood also have the appearance of being in retreat. (*Rusk.*)

The snowfall in the neighborhood of Mount Hood was unusually large in the spring of 1904, as it has been for the last few years. (*Gorman.*) Nevertheless, the Zigzag glacier on the west side of Mount Hood seems to have become smaller since last year. (*Knapp.*) The snowfall was very heavy in the Sierras this year; in the late summer the Lyell glacier was still almost entirely snow-covered, and deep drifts extended beyond the limit of the ice. It shows no definite retreat since Professor Russell visited it in 1883. The accumulation of snow seems to have been increasing during the last two or three years, and "there is good reason for believing that the glacier is slowly advancing." Lake Mono, at the foot of Mount Lyell, without any outlet, has been slowly rising for many years. This seems to indicate an increase of precipitation in the region and may foreshadow a general increase in the size of the glaciers. (*Lee.*)

The Arapahoe glacier in Colorado shows no definite change since last year. (*Henderson.*) The Hallet glacier, a little farther north, has diminished in the last nine years, but there is no definite information with regard to its more recent changes. (*Mills.*)

The subject of glacial erosion is being vigorously attacked from the standpoint of physiography. Mr. Willard D. Johnson[1] describes the forms of old glacial valleys in the Sierras, dwelling especially on the very low grade, occasionally even reversed, in the upper part of the old glacial troughs. This form bears no relation to the profile produced by stream erosion, and he therefore thinks that it is to be accounted for by the erosion of the ice. He describes a descent into the bergschrund of one of the smaller Sierra glaciers, where he found the rock impregnated with water melted from the ice, and the broken nature of the rock led him to believe that much sapping was accomplished at this point by the frequent freezing and melting of the water. This led to the belief that sapping of this kind explained the glacial erosion. Mr. Johnson has since given up this idea, because the bergschrund must be shallow in comparison with the depth of the ice; but he thinks that the line of the ancient bergschrund can still be recognized by a very steep cliff in the upper part of the walls of the cirques of the Sierras.

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[1] "The Profile of Maturity in Alpine Glacial Erosion," *Journal of Geology*, Vol. XII (1904), pp. 569–78.

Mr. G. K. Gilbert[1] confirms the existence of a "schrundline," and brings out the interesting fact that a distinct difference in slope often exists on opposite sides of ridges in the high Sierras. The steeper side is that on which the snow would naturally accumulate as a result of the prevailing winds and of protection from the snow. He therefore concludes that the glaciers formed from the snow have by erosion steepened the slopes. In the volume of the Harriman Alaska Expedition on *Glaciers and Glaciation*, briefly noticed in last year's report, Mr. Gilbert presents a very strong argument in favor of the great erosive action of glaciers.[2]

Dr. Albrecht Penck[3] discusses the action of glaciers in the Alps, and shows how very difficult it is to explain all the physiographic features of glacial valleys without assuming that these valleys have been eroded by the glaciers.

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[1] "Systematic Asymmetry of Crest Lines in the High Sierras of California," *ibid.*, pp. 579–88.

[2] *Glaciers and Glaciation*, Harriman Alaska Expedition, Vol. III (New York, 1904).

[3] "Glacial Features in the Surface of the Alps," *Journal of Geology*, Vol. XIII (1905), pp. 1–19.